A life stage development index for *Trypodendron lineatum* (Oliv.) in a spruce boom on the Alberni Canal, Vancouver Island

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ABSTRACT

Development of *Trypodendron lineatum* Oliv. was monitored in a high-grade log boom of Sitka spruce, *Picea sitchensis*, stored in the Alberni Canal, B.C. in 1991. Twenty-eight logs were surveyed at weekly intervals from April 19 to September 13, 1991. By the sixth week all 28 logs had been attacked. Every week, chunks of wood were cut from each attacked log and total of all life stages were recorded. Changes in insect development and the presence or absence of stain were noted. The ratio of brood adults to parental adults was 10:1 and it was determined that the timing of both parental and brood adult emergence coincided in the "sister" flight. An insect development profile was constructed from these data, and an index was produced for estimating the minimum number of days required to reach specific stages in development. When combined with logging and transportation information, the index provided an estimate of where and when the logs had been attacked. With this information, modifications in management strategies can be reviewed and steps taken to avoid pest populations being transported to storage areas.

Key words: *Trypodendron lineatum*, ambrosia beetle, life stages, stain, insect development index.

INTRODUCTION

The ambrosia beetle, *Trypodendron lineatum* (Olivier.), is a serious pest to the forest industry and has caused extensive degrade to high-grade logs in coastal British Columbia (Kinghorn and Chapman 1959; Dyer 1963; Gray and Borden 1985; McLean 1985). The clear outer part of the log is the preferred habitat for shelter and brood production of the ambrosia beetle (Shore 1985; Borden 1988). Degrade results when the valuable outer portion of these logs has darkly stained pinholes as a result of ambrosia beetle activity. The lumber is downgraded or rejected from specific markets.

In mid-April ambrosia beetles fly from their overwintering sites in the duff on the forest floor. Host volatiles arrest the emerging beetles at felled or stored log inventories where they colonize the sapwood (Borden 1988). Once the wood has been penetrated by the beetles it becomes stained by the action of symbiotic dark staining fungi. The larvae and parental adults feed on the ambrosia fungus while the brood develops. The adult beetles tend the brood inside the log by keeping the galleries clear of frass and by cropping the growth of the fungus in the galleries. In late summer, after a short maturation period, parental and brood adults leave the logs and fly to the forest margin to overwinter.

Considerable efforts have been invested in the development of control strategies involving insecticides (Richmond 1969), trapping studies using pheromones (McLean and Borden 1975; Shore and McLean 1984, 1985; Lindgren 1990) and other methods of integrated pest management (Richmond and Nijholt 1972; Nijholt 1978; Borden 1988; McLean and Stokkink 1988). In spite of this knowledge, logs are still being attacked in the forest and insects are being spread extensively throughout the transportation system (McLean 1991).

In coastal B.C., log inventories accumulate in booming grounds and storage areas prior to processing. In some cases, depending on supply and demand of certain sorts, this wood can remain in storage for a considerable length of time. If infested logs are left in storage areas and sorting grounds at the time of brood emergence in summer, they become the source of the following season's spring attack flight beetles. Teneral adults will emerge, and overwinter in adjacent forested margins.

As early as 1950, Graham et al. (1950) researched the use of indices to measure and assess the degrade caused by ambrosia beetles. The issues of breeding sites and population estimates were explored by Chapman (1974) and Von Popo and Thalenhorst (1974). There is a need to know where and when ambrosia beetles attack high value logs. Identification of high hazard areas can assist in the development of strategies to direct log inventory flow. Log inventory control can be implemented in the forest, in the sorting areas and the log storage areas in order to reduce the chances of ambrosia beetle attack on high value saw logs.

Studies were carried out in the Alberni Canal on Vancouver Island to develop a method where life stages could be used as indicators to estimate the timing of the original attack on a log. There were two main objectives: first to observe the life stage development of *Trypodendron lineatum* over time and to identify key changes in insect development and conditions in attacked logs; and second to prepare a life stage development index to estimate where and when the attacks occurred.

METHODS AND MATERIALS

On April 3 1991, sawlogs of Sitka spruce, *Picea sitchensis* (Bong.) Carr., were transported by barge from the west coast of Vancouver Island into the Alberni Canal. Timber marks and inventory information indicated that the logs had been cut between February and March 1991. These logs were sorted in the Alberni Canal. Both bundles and large loose logs were put into the boom. After the boom was completed on April 18 1991, it was towed out for storage along the shore of the Alberni Canal, some 2 km south of Port Alberni.

The first survey of the boom was conducted on April 19, at which time all of the non-submerged logs were surveyed. A total of 28 logs were tallied and numbered for further survey. Between April 19 and September 13 1991, each of the 28 logs were searched at weekly intervals for signs of infestation as indicated by the presence of white boring dust initially and later, entry holes. Most logs were sampled each week as long as the galleries were accessible. If a log had been attacked, a chunk of wood containing the entrance hole to a gallery was chopped from the log. The chunk measured approximately 20 cm. square, and was cut as deep as the insects had penetrated.

TABLE 1

Insect Development Index for *Trypodendron lineatum* constructed from data generated during a 22 week survey of a spruce boom in the Alberni Canal from April 19 to September 13, 1991.

Life stages and visible symptoms	Estimated time since attack (days)
Adults only present (no niches)	0-10
Adults; evidence of gallery construction (egg niches present; some light staining)	11-20
Adults and eggs; niches present (some dark staining)	21-28
Adults, eggs and early instar larvae (wood darkly stained)	29-35
Adults, eggs, late instar larvae and pupae	36-48
Adults, eggs, larvae, pupae and teneral adults	49-84
Adults larvae, pupae, teneral adults present; empty pupal niches	85-105
Attacked, stained with empty pupal niches and no life stages	>105 days

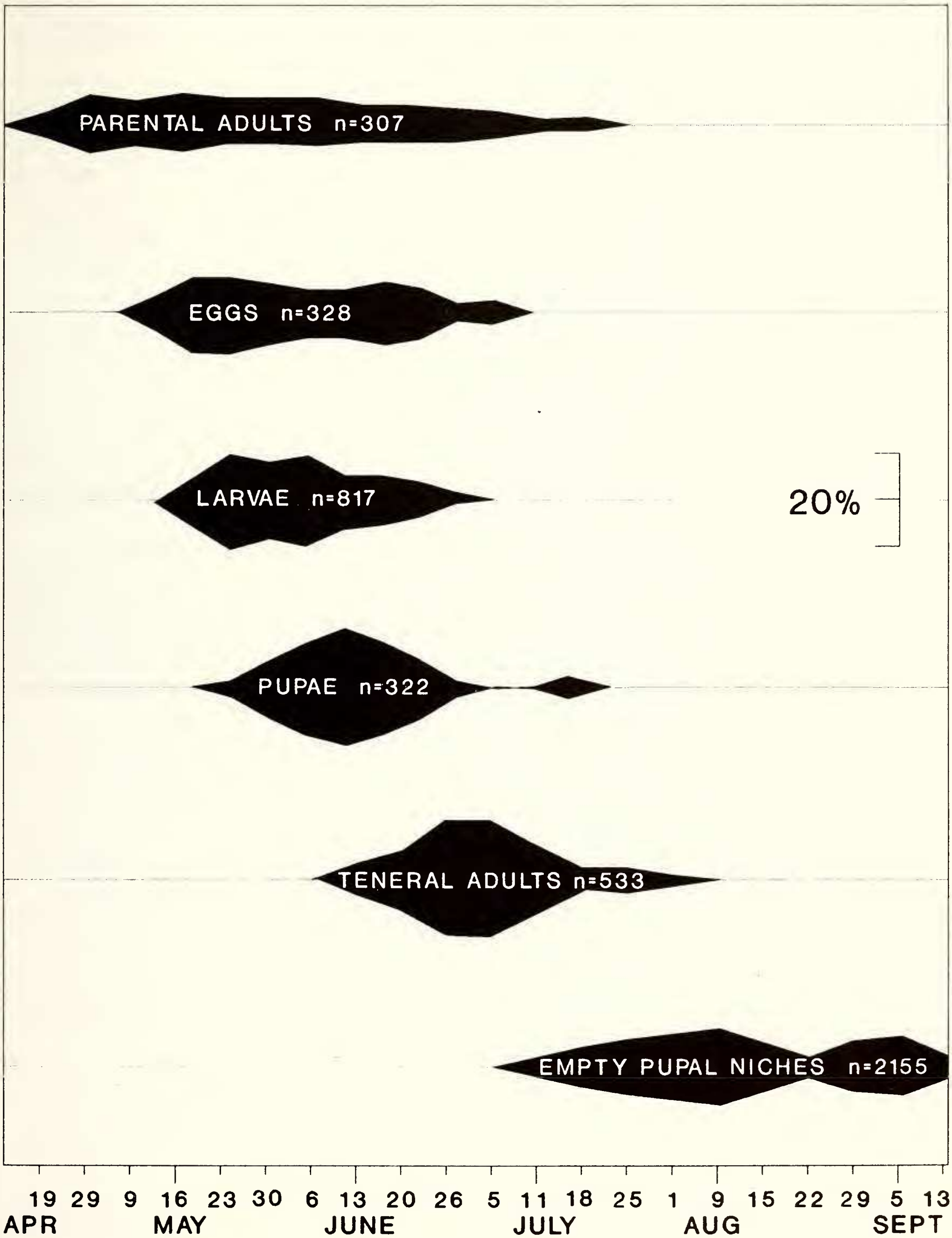

Figure 1. Kite diagrams to show the relative abundance of the life stages of the ambrosia beetle *Trypodendron lineatum* (Oliv.) over time in a log boom of Sitka spruce, *Picea sitchensis*, in the Alberni Canal, during the summer of 1991.

The chunk of wood was then carefully dissected with a pocket knife to expose all insect life stages. Counts of all parental adults, eggs, larvae, pupae and teneral adults were recorded as well as the sex of parental adult(s), depth of penetration, presence of niches, and presence and development of stain.

The total numbers of each of the life stages found at every time interval were summed. From this information, an insect development profile was constructed to trace the number of each life stage present in the logs over time. Since there was so much variability in attacks both within and between logs and because the survey required destructive sampling, this information was best represented in a "kite" chart to show the relative abundance of each life stage over time.

RESULTS AND DISCUSSION

The development profile for each life stage in time and the overlap between life stages is shown in Figure 1. It is particularly interesting to note that the number of parental adults present in the galleries declined at about the same time the teneral adults reach their peak. The ratio of teneral to parental adults was calculated as 10:1. The decline in the number of teneral adults from July 5-18 corresponded with the first empty pupal niches. This indicated that the teneral adults were leaving the niches but were still active in the galleries. Finally, the parental and teneral adults left the logs at about the same time around the middle of July.

The profiles were then used to construct the life stage development index. The premise of this index is that all time increments are minimum estimates. The estimated time since attack represents the minimum time leading to the presence of substantial numbers of each specific life stage or other gallery phenomena.

For the first 10 days of the survey only adults were present. Activity at this time suggests that the adults had located a potentially suitable habitat and had initiated "aggregation". At the time of the first survey, the mean penetration by adults was 8.4 mm. which, from our observations suggested that the attack was no more than two days old. The initial attack date was April 18, 1991. In this establishment phase, there was a period of at least ten days when only adults were present before any signs of niches or staining were found. This was the first of the components of the insect development index (Table 1).

Between the first and second surveys, the attacking insects had mated and begun to excavate the galleries. At this time there were no lateral galleries found. By the time of the second survey, 70% of the beetles were paired. In all cases, the female was at the head of the gallery while the male was actively clearing boring dust from the gallery. Many of the females were found in the lateral galleries and one egg niche was found indicating active brood gallery construction. At this time there was evidence of light staining around the gallery walls. Thus, from 11 days and up to 20 days, after the initial attack the presence of adults, gallery construction, egg niches (but no eggs), and some light staining was seen.

Between the second and the third surveys egg niches were constructed and oviposition had occurred. The first sign of eggs occurred 21 days after the initial attack and dark staining was present in the galleries. Although by May 16, 28 days after the initial attack, adults and eggs were present and there was still no evidence of larvae.

In the period between May 16 and May 23, 29 and 35 days respectively after the estimated initial attack, eggs had hatched and by the 23 May a total of 83 larvae were found. Therefore, there was a period of 14 days after the first eggs were seen before larvae were found. Nijholt (1978) estimated that eggs require 8-10 days to hatch. In this case, our data support that estimate, if egg hatch had started shortly after the survey on May 16.

Larval development was evident 29 days after the initial attack, and by May 30 (after 36 days), the number of larvae present had reached a peak, and late instar larvae were present. In addition, a few of the more advanced larval instars had developed into pupae. By June 6, 49 days after initial attack, parental adults and eggs were present and some of the pupae had developed into teneral adults. The first empty pupal niches were found on July 11 after 84 days. At this time, larval stages were still present. In early August, 105 days after the first signs of attack, there were no life stages present. There was an abundance of empty pupal niches and the wood was heavily stained.

This index can be combined with harvesting and transportation data to estimate where and when the attack could have occurred, and more importantly to predict when the adults will emerge to overwinter. If an estimate of the time of emergence is known, decisions can be made as to the storage location of booms to protect storage and sorting areas; or schedule processing to use the higher risk booms at this critical time.

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